The Isotropy of the Speed of Light and its Implications

AN INFOPHYSICS MONOGRAPH

ON

SPECIAL RELATIVITY AND GENERAL COSMOLOGY

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Revision published at ResearchGate, February 2016. Edition 1.0.1

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ABSTRACT

This monograph reexamines the basics on the motional properties of light and of material particles in an attempt to resolve as many of the questions and paradoxes posed by the different interpretational scenarios of Special Relativity (SR). The observational process is clarified and defined in terms of measurements by the use of standard rulers. Motion invariant rulers vs. motion variant rulers are considered under different interpretational scenarios of SR. The isotropy of the speed of light and particle trajectories in general are then considered under the different interpretational scenarios of SR to clarify their implications together with the behavior of de Broglie matter-waves, in reference to their motional geometry. In conclusion, a 3D spherical manifold (S^3 *hypersurface) is proposed for the motional geometry of the Universe.*

SUGGESTED READING

In order to better understand the content of this monograph, the reader should be familiar with the following monographs written by the author:

Title	Subject
Reality Unveiled (1).	The defining essay of Infrarealism, an immaterial ontology.
Spacetime Unveiled (2).	An infophysics monograph proposing the Infophysical Spacetime Model (ISM).
Mass-Energy Unveiled (3).	An Infophysics Monograph. Relates the mass-and energy properties to the single fundamental property spatial density (spatial frequency).
Special Relativity Unveiled (4).	An Infophysics Monograph. Derives Einstein's Theory of Special Relativity (SR) in terms of the ISM (2).
Fundamental Constants Explored (5).	An infophysics monograph on the criteria that should be considered in order to establish the legitimacy of a *fundamental* constant of Nature.
Matter-waves and Discrete-transitional Motion (6)	An Infophysics monograph. A derivation of the de Broglie matter-waves transitional relations and their discrete motion.

You can find links to all the available *Reality Unveiled Collection* monographs at the end of this one.

REVISION HISTORY

Rev.	Date	Description	Published at:
1.0.0	5/2/16	Initial document.	Gumroad.
1.0.1	5/2/16	First posting.	Research Gate. DOI: 10.13140/RG.2.1.1085.8005
1.0.1	6/2/16	First posting.	Academia, Vixra.

INTRODUCTION

It is a physical fact that matter sometimes behaves as particles and other times as waves. There is no doubt that de Broglie matter-waves are a reality, and that fact has been demonstrated in innumerable experiments since their proposal.

An objects behavior is defined by its properties. If an object's properties are categorized under some common set of characteristics, the categorization does not necessarily change the structure of the object. Consequently, in order to resolve confusion, I will use in this monograph, the term *particle* to refer to an object's material properties and the term *wavicle*[1] when referring to its wave-packet properties. In other words, the question whether a particle is structurally matter or wave, is irrelevant for this discussion. For clarity, I will retain the term *wave*, when referring to non-packet wave types, such as sound waves or light.

It is the purpose of this monograph to resolve the confusion caused by matter-wave ambiguities and to utilize their particle-wavicle properties to determine what those properties specifically imply within different interpretational scenarios of Special Relativity (SR) and within General Cosmology.

The propagation speed of waves

The propagation speed of a wave is given by,

(1) $v = \lambda f$, where,
v is the wave's propagation speed,
λ is its wavelength and
f is its temporal frequency.

The above equation can be interpreted very simply, the speed (v) of a wave is equal to its wavelength (λ : the interval of displacement (length) in-between each of its spatial cycles), multiplied by its temporal frequency (f : the number of temporal cycles in-between one reference temporal cycle). The units for the speed of waves are therefore, spatial-intervals/temporal-cycle, which in SI units, turns out to be meters/second.

The propagation speed of light waves

The propagation speed of light waves is given by the same relation *(1)* of a regular wave, except for its symbology, where the standard symbol c used to represent the speed of light replaces the symbol v,

(2) $c = \lambda f$, where,
c is the propagation speed of light,
λ is its wavelength and
f is its temporal frequency.

Before about a century ago, there was nothing special about the propagation speed of light; light was thought to behave like any other wave, until Albert Einstein appeared on the scene in 1905.

[1] The term *wavicle* in this context refers to the wave properties of objects, as in de Broglie matter-waves. The term *wavicle* was coined by Arthur Eddington in 1928.

THE ISOTROPY OF THE SPEED OF LIGHT

Based on experimental data that seemed to indicate that the speed of light was constant independently of direction and of the speed of its source[2], Albert Einstein published in 1905, his Special Relativity theory, where he established as one of its postulates the isotropy and constancy of the speed of light:

> *...the speed of light in a vacuum is the same for all observers, regardless of the motion of the light source.*

The above postulate (let's call it the isotropy postulate) has avoided verification, because the one-way speed of light is very difficult to measure, if not impossible, due to clock synchronization issues, thus a direct proof has not been established. Nonetheless, this is not the case with SR and some of its conclusions/predictions; therefore we can safely assume that the postulate is valid.

OBSERVATIONS/IMPLICATIONS

The isotropy of the speed of light means that the c in *Eq. (2)*, is a scalar constant, so based on that equation, let's try to determine what the isotropy of the one-way speed of light implies.

Observations on *Eq. (2)*

Because the isotropy postulate clearly states "*...for all observers*", we first need to establish what to *observe* means. To *observe* ultimately means to measure with some standard reference ruler. In the case of space the reference ruler has numbered (distinguishable) spatial intervals on it and in the case of time the ruler is some kind of reference clock with numbered (distinguishable) temporal intervals. We can refer to both types of rulers as spatiotemporal reference (STR) rulers. For the sake of clarity then, to *observe* the speed of light means *to measure the speed of light by comparing it to some STR ruler*. The same thing goes for λ and f of *Eq. (2)*.

In regards to the significant use of STR rulers for measurement, I can see only two viable possibilities, either, invariant STR rulers exist or they don't. Invariant means in our context that the STR rulers are invariant to motion. Obviously, the STR rulers must also be invariant to their displacement, that is, they are also invariant to where they are (invariant everywhere). I suppose there is a possible combination of STR rulers where one type is invariant and the other one isn't, but I don't want to complicate things beyond sanity.

If invariant STR rulers exist

Let's look at the interpretational scenario where invariant STR rulers exist. In this case *Eq. (2)* implies that, under motion and c postulated as a scalar constant:

[1] If the wavelength of the wavicle contracts/dilates, its temporal frequency <u>must</u> do the opposite, dilate/contract.

[2] If the temporal frequency of the wavicle contracts/dilates, then its wavelength <u>must</u> do the opposite, dilate/contract.

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[2] Wikipedia Jan 2016, Michelson-Morley experiment.

[3] *Eq. (2)* relates to more than a propagation speed, it is a relationship that holds independently of a wavicle's group velocity, light is just a special wavicle that propagates at a speed with that same value. For example, an electron's Compton wavelength is related to its Compton frequency by *Eq. (2)*, regardless of the electron's speed, although its group velocity is not equal to c.
The Lorentz transformation does not hold for photons, because photon frequency does not change as photons are slowed down, as in dispersive media for example. This suggests that the speed of light c and some other constant (call it c_0), are two different animals that look the same (have the same value) under one particular circumstance. Additionally, this suggests that **photons are more like *transactional events* than wavicles**, because their frequency does not change as they slow down though dispersive media.

Because [3] is a very important observation, we need to restate *Eq. (2)* as follows,

(3) $\lambda f = c_0$, where,
c_0 is a cosmic spatiotemporal constant, not the propagation speed of light.
(You may refer to (5) for a detailed explanation as to the nature of ST scale-constants).

Stated in this form, I believe we have found in *Eq. (3)* an absolute reference for our desired motion invariant STR rulers, as I will explain later.

Furthermore, we can very easily discern from the above that the same relationships also hold between the wavicle's wavelength and its kinetic energy; therefore, the same relationships must also hold between the wavicle's wavelength and its kinetic mass and momentum.

No problems so far, except for the photon's disobedience of SR under dispersion. Nevertheless, what SR is saying in this interpretational scenario, is that if the motion of a wavicle changes, its wavelength changes according to the Lorentz transformation; all other related properties follow suit from there.

If invariant STR rulers do not exist

So far so good, now let's look at the interpretational scenario where invariant STR rulers do not exist. In this case *Eq. (3)* implies that, under motion:

[4] If the wavelength of the light contracts/dilates, the spatial ruler <u>could have</u> expanded/contracted or the wavelength really contracted/dilated.
[5] If the temporal frequency… Ditto.

Basically, when measuring with variant STR rulers, *Eq. (3)* implies nothing. By nothing, I mean nothing about the real contraction of the wavicle's wavelength. When SR is interpreted under this scenario, it's no wonder that it has so many inconsistencies and paradoxes lurking around.

Before we go on, I need to emphasize that,

[6] SR deals with the dynamics of objects in the absence of gravity, which means that *Eq. (3)* must hold everywhere, which renders motion-variant STR rulers inconsistent and paradoxical.

Let's look at one more aspect of the isotropy postulate. Isotropy means "in all directions", this aspect is not explicitly mentioned in SR, but it is implied in "*…regardless of the motion…*" Nevertheless, let's examine this aspect of the isotropy postulate in the interpretational scenario that considers the existence of invariant STR rulers. The variant STR ruler interpretational scenario, we have already established, implies nothing useful.

Isotropy using invariant STR rulers

The isotropy of light means that *Eq. (3)* holds everywhere and in all directions, therefore it is a property of the *motional geometry* of the Universe. In other words:

[7] *Eq. (3)* is a property of the geometry of all the <u>isolated trajectories</u> (no forces) allowed in the Universe. Furthermore, on closer examination, we can see that it deals with its motional properties only, obviously because sinusoidal waves are cyclic by definition, which in turn implies that all the motional properties of wavicles are circular (bound by circles).

Let's express in words, once more, what *Eq. (3)* is telling us:

[8] For every isolated wavicle (no forces), everywhere, and in all possible directions, the displacement of one of its spatial cycles, multiplied by, the number of cycles in one reference temporal cycle, is a scalar absolute (cosmic) constant.

If we examine observations [7] and [8] closely, we can see that they define an invariant STR ruler in terms of STR cycles. Our STR ruler looks as follows (remember that our STR ruler <u>has to be</u> some kind of a wavicle also):

Fig. 1 — STR Ruler 1.

<table>
<tr><td colspan="10" align="center">$one\ reference\ temporal\ cycle$</td></tr>
<tr><td>λ_1</td><td>λ_2</td><td>λ_3</td><td>λ_4</td><td>λ_5</td><td>λ_6</td><td>λ_7</td><td>λ_8</td><td>$\rightarrow$</td><td>λ_f</td></tr>
<tr><td colspan="10" align="center">c_0</td></tr>
</table>

Our STR ruler may look unfamiliar because we are used to looking at *Eq. (3)* in SI units, while the above STR ruler is in terms of displacement and temporal cycles and is therefore enumerable (countable, as represented by the index of the spatial displacement λ). Nevertheless, STR Ruler 1 represents the same relationship stated by *Eq. (3)*, except for its integer/enumerable form. You will recognize this type of STR ruler as the type used to measure astronomical distances in terms of light years, in which case the spatial reference displacement is taken to be one meter and the reference temporal cycle is one year.

STR Ruler 1 is a general ruler and it is not very useful if λ is not defined. Therefore, in order for STR Ruler 1 to be useful we need to define a standard λ, like it was done for the light year ruler.

Our intent here is to try to measure the extent of the possible trajectories of the Universe using an appropriate STR ruler. A ruler like the light year ruler is not adequate because its units are arbitrary, namely SI units. We need an STR ruler specified in spatiotemporal "natural" cycles where the value of the standard spatial displacement is the smallest possible, so that we can maximize the number of its temporal cycles, thus its resolution. We will call this ruler the Cosmic STR Ruler and define it as follows:

Fig. 2 — Cosmic STR Ruler

$one\ cosmic\ reference\ temporal\ cycle$									
$\lambda_{\gamma 1}$	$\lambda_{\gamma 2}$	$\lambda_{\gamma 3}$	$\lambda_{\gamma 4}$	$\lambda_{\gamma 5}$	$\lambda_{\gamma 6}$	$\lambda_{\gamma 7}$	$\lambda_{\gamma 8}$	$\rightarrow$	λ_{A_γ}
$\lambda_\gamma A_\gamma$									

Where:

λ_γ Remains the smallest displacement possible. You may notice the use of the subscript γ to denote the stellar (cosmic) scope as established in (2),
A_γ is the largest possible number of cycles in one cosmic reference temporal cycle and
$\lambda_\gamma A_\gamma$ is the total displacement (length of the ruler).

With the Cosmic STR Ruler in hand let's apply it to different motional geometries to try to determine the extent of their possible trajectories, as well as the characteristics of that particular geometry.

Euclidean (flat) geometry

The following are observations on a Euclidean motional geometry:

[9] All trajectories allowed for an isolated wavicle are straight lines, in which case, our cosmic ruler would not be very useful because straight line trajectories have infinite extents.
[10] Natural motion follows straight lines and therefore follows Newton's second law. This means that cyclic trajectories are not allowed without the influence of forces. Consequently, **a cosmic reference temporal cycle is indefinable (infinite), making the definition of a cosmic STR ruler impossible**.
[11] If the definition of a cosmic STR ruler is impossible, then neither the constancy of c or of c_0 have any basis for measurement and must remain a postulate.
[12] The isotropic postulate is possible, but meaningless. Meaningless in the sense that it provides very little information, because our cosmic ruler is indefinable.

If the motional geometry of the Universe is Euclidean, there isn't much that *Eq. (3)* can imply and we are up the creek.

Spherical Geometry

The following are observations on a 3D spherical hypersurface[3] (**S^3**) on a 4D spherical geometry:

[13] All trajectories allowed are geodesics (great circles) around which we can wrap our cosmic ruler.
[14] The isotropic postulate is possible and meaningful because all geodesics passing through every point have an identical finite extent (circumference) and a closed curvature.
[15] Natural motion is along geodesics. This means that cyclic trajectories <u>are</u> allowed without the influence of forces. Consequently, a cosmic reference temporal cycle <u>is distinguishable</u>, making the definition of our cosmic STR ruler possible.

[3] This type of geometry for the Universe was originally proposed by Albert Einstein in 1917, he later abandoned it to include his cosmological constant in GR theory.

[16] The definition of our cosmic ruler is possible; consequently the constancy of the speed of light, by coincidence, has a basis as an ST scale-factor (5) and should be derivable from the motional geometry of measured wavicles.

[17] SR and the Lorentz transformation can be readily derived (4) from its motional geometry.

[18] The dynamics of stellar wavicles imply an $\mathbf{S^3}$ motional geometry. I refer you to *Matter-waves and Discrete-transitional Motion* (6).

[19] We are still left with the same troublesome property of Euclidean motional space, which is the inability to distinguish an absolute origin, because all coordinates on $\mathbf{S^3}$ have identical properties and so do all geodesic trajectories. This means that it is not possible to distinguish an absolute inertial reference frame from any other.
It turns out that SR does not care about this property, this <u>is</u> what "relativity" is all about, in other words, all displacements and all velocities are relative.
What causes the paradoxes is not the isotropy of motion, but the interpretational scenario where invariant STR rulers are not definable, in other words, where the spatial and temporal dimensions are allowed to contract/dilate under motion. This kind of scenario is unreasonable, because motion is a property of wavicles not of space. Imagine what would happen to an image in a computer display if we allowed the screen to locally dilate/contract as the image races across it.

In an $\mathbf{S^3}$ motional geometry, the parameters of the cosmic STR ruler acquire the following meanings:

[20] λ_γ Remains the smallest displacement cycle possible,
A_γ is the largest possible number of cycles in one cosmic reference temporal cycle and the radius of the 4D sphere,
$2\pi\lambda_\gamma A_\gamma$ is the total displacement (length of the ruler) and the circumference of all geodesics and,
A_γ also becomes the parameter that determines the scale of the stellar scope of Reality (2), a *scopal ST scale-constant* (5),

CONCLUSIONS

[21] Motion invariant STR rulers cannot be applied in a Euclidean motional geometry.

[22] An interpretational scenario of SR where invariant STR rulers do not exist is not viable. This is the currently accepted interpretational scenario of SR, thus the paradoxes and the inconsistencies with simultaneity.

[23] SR cannot be unambiguously verified or falsified in a Universe with Euclidean motional geometry.

[24] An $\mathbf{S^3}$ spherical motional geometry allows the definition of an invariant cosmic STR ruler based on *Eq. (3)*, therefore a meaningful interpretation of SR and de Broglie-matter waves is possible (6).

[25] In an $\mathbf{S^3}$ spherical motional geometry, the speed of light approaches the value of the stellar scale-constant as a true vacuum is approached.

[26] Using the relativistic de Broglie matter-wave (wavicle) relations, we can represent the natural motion of a particle as the wave traced by the particle's trajectory around one of the geodesics (great-circles) of $\mathbf{S^3}$.

[27] Compton wavicle properties belong to the atomic scope, de Broglie wavicle properties belong to the stellar scope.

[28] The motional constraints imposed by *Eq. (3)*, Special Relativity and the physical existence (or the interpretation) of wavicle properties, imply an $\mathbf{S^3}$ motional geometry for the Universe, notwithstanding, that other motional geometries need to be considered.

REFERENCES

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4. —. *Special Relativity Unveiled.* Jinotepe : s.n., 2014. Infophysics Monograph. RPI No: 000748.

5. —. *Fundamental Constants Explored.* Jinotepe : s.n., 2014. Infophysics Monograph. RPI No: 000944.

6. —. *Matter-waves and Discrete-transitional Motion.* Jinotepe : s.n., 2016. Infophysics Monograph. RPI No: 001072.

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